Adaptively combined delay-and-sum beamformed subarrays

Andreas Austeng[1], Yücel Karabiyik[1], Jan Egil Kirkebø[1], Ole Marius Hoel Rindal[1]
[1]University of Oslo, Oslo, Norway

Background, Motivation and Objective

Minimum variance (MV) beamforming offers improved lateral resolution. It has successfully been demonstrated to satisfy the real-time processing requirements for cardiac applications. However, the method has not been implemented in any commercial system due to its multiple orders of magnitude higher computational load compared to the conventional delay-and-sum (DAS) beamformer. Several algorithms have been suggested to reduce the needed amount of computations. Most of these requires a large increase in memory and data handling.

Statement of Contribution/Methods

In this work, we suggest a partially adaptive beamforming algorithm that processes the data in two steps. The array is divided into subarrays. First conventional DAS is used to combine the data in the different subarrays. Instead of summing the output of these subarrays, and thereby forming the DAS output, the outputs are combined adaptively using the MV beamformer. The computational complexity of the MV beamformer scales with three orders of magnitude to the number of elements. By reducing the effective number of elements with a factor M, where M is the length of the subarray, the computational complexity is reduced with a factor M^3.

To demonstrate the imaging performance, phantom data is recorded with the Verasonics Vantage system using a 64-element phased array, and beamformed using implementations in the UltraSound toolbox.

Results/Discussion

The figure shows B-mode images of a point target, a hyper-echoic area, and speckle, processed using a DAS, MV, and a two-stage DAS-MV algorithm. For DAS-MV, subarrays of size 8 have been combined using DAS. The same parameters have been used for the MV and DAS-MV, except that MV inverts covariance matrices of size 32x32, and DAS-MV inverts 4x4 matrices. The number of computations is in this example reduced by a factor 500. Visually, the MV and DAS-MV produce similar images of higher resolution than DAS. A radial cut through the point target, indicated with the dashed white line in the DAS image, is shown in the lower right quadrant. It shows that DAS-MV preserves the MV resolution, and in addition avoids some of the signal cancellations observed with the MV beamformer. The increased resolution and the computational efficiency make the DAS-MV a good candidate for MV beamforming in standard ultrasound imaging.